

Bats (Chiroptera: Vespertilionidae) of the Great Dismal Swamp of Virginia and North Carolina

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ABSTRACT.— From autumn 1983 through spring 1986, bats were collected in the Dismal Swamp, a forested wetland located in southeastern Virginia and northeastern North Carolina. Before this survey, only five species of bats were known from the Dismal Swamp, all first collected during the 1890s. A total of 89 specimens representing five genera and seven species were collected, including 50 red bats, *Lasiurus borealis*. Four species are new records for the Dismal Swamp, and the one specimen of Seminole bat, *Lasiurus seminolus*, represents a first record for Virginia. During winter, the population of red bats consisted entirely of males, which were active at ambient temperatures $\geq 10^{\circ}\text{C}$. Five species of bats are considered permanent residents; two of these were active throughout the year and the others hibernated during the winter months.

Five species of bats from the vicinity of Lake Drummond (Table 1) were collected between 1895 and 1898 by A. K. Fisher and William Palmer, of the U.S. Department of Agriculture's Bureau of Biological Surveys, during a survey of the Great Dismal Swamp, an 80,000-ha forested wetland on the coastal plain of Virginia and North Carolina. The first records of bats from the region (although not from the Dismal Swamp proper) had been made between 1891 and 1894 by the Smithwick brothers in the Albemarle Sound area of Bertie Co., N.C. (Brimley 1897).

Since the 1890s, no systematic attempt had been made to study bats in the vicinity of the Dismal Swamp. Handley (1979a), after an exhaustive review of the literature, compiled a short account of the species of bats believed to occur in the Dismal Swamp forests (Table 1). He attributed 10 species of bats to the Dismal Swamp, but only five species had been collected there; the remainder were collected near Albemarle Sound by the Smithwicks or in other areas adjacent to the Dismal Swamp. The four records from the twentieth century include three specimens from the Dismal Swamp: one Keen's myotis, *Myotis keenii* Merriam, in 1930, and two eastern pipistrelles, *Pipistrellus subflavus* F. Cuvier, in 1905 and 1964 (Handley 1979a); the fourth is a

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yellow bat, *Lasiurus intermedius* Allen, found in Norfolk in 1954 (de Raageot 1955).

Our objective was to determine the species of bats that currently inhabit the Dismal Swamp compared with the ones there 90 years ago. Because much of the Dismal Swamp is now incorporated into a federal wildlife refuge, present-day information regarding the presence and abundance of species of bats is important in the long-term management of the Great Dismal Swamp National Wildlife Refuge (GDSNWR).

METHODS

In the Dismal Swamp, previous attempts at mist-netting bats proved unsuccessful (C. O. Handley, Jr., and D. Lahti, personal communications), primarily as a result of dispersal of flying bats over vast areas of flooded forests and the tendency of some bats to forage at or above the forest canopy. Because our objective was to compile a record of the bats of the Dismal Swamp, we elected to collect voucher specimens by shooting. In that way, a permanent record of the bats of the Dismal Swamp at the present time is established, and the value of the voucher specimens will increase with time.

We collected bats using 12- and 20-gauge shotguns bored to improved cylinder (O'Conner 1965) and loaded with standard 8- and 9-shot loads. In good light conditions, we quickly learned to identify red bats, *Lasiurus borealis* Müller, in flight, and therefore were often able to record their distribution and emergence times without having to collect additional specimens.

Sampling sites were restricted to open areas within the Dismal Swamp, usually within the GDSNWR, such as roadways and road intersections, which offered clear avenues for collecting. Lake Drummond, a 1,000-ha natural lake located in the approximate center of the Dismal Swamp, was sampled from shore and from a boat. Two old abandoned buildings along the shore of Lake Drummond were searched unsuccessfully for bats.

Collection times were limited approximately to sunset ± 0.5 hour. For each species, we recorded ambient temperature, local weather conditions, and the time of emergence, defined as the time in minutes before and after sunset that a species of bat was first observed or collected. We collected only during the months of September through early June; from late June through August, bats produce young and rear them to flying age.

The specimens collected during the survey were preserved either as study skins and skulls or in 70% ethanol. They have been deposited at the U.S. National Museum of Natural History (USNM 448240-312; 448314-317; 448319-331).

RESULTS

From 5 October 1983 through 15 March 1986, we spent 77 evenings collecting bats (Table 2). We collected a total of 89 specimens representing five genera and seven species. Four of these species are new records for the Dismal Swamp: the big brown bat, *Eptesicus fuscus* (Palisot de Beauvois); the silver-haired bat, *Lasionycteris noctivagans* (LeConte); the hoary bat, *Lasiurus cinereus* (Palisot de Beauvois); and the Seminole bat, *Lasiurus seminolus* (Rhoads).

The silver-haired bat was active and relatively common during the winter months. Eight were collected (Table 2), indicating that this bat is relatively common in winter. Although we collected only eight specimens, we observed silver-haired bats on several occasions during December and January throughout the Dismal Swamp. Sometimes we saw these bats emerging from hollow bald cypress trees, *Taxodium distichum*, growing in Lake Drummond. In good light, silver-haired bats could be distinguished by their nearly black coloration, and they often flew in

Table 1. Historical records of the 10 species of bats previously thought to occur in the Great Dismal Swamp (Handley 1979a) compared with the species of bats found there during the present study.

Species	Location and year(s) collected	Number collected		Present in swamp	
		Previous/Current	Previous/Current	Previous/Current	Previous/Current
Little brown bat	Bertie Co., N.C., 1891-1893	3	0	no	no
Keen's myotis	Lake Drummond, Dismal Swamp, 1896, 1930	2	0	yes	no
Silver-haired bat	Bertie Co., N.C., 1891-1892	6	8	no	yes
Eastern pipistrelle	Lake Drummond, Dismal Swamp, 1895, 1905, 1964	6	6	yes	yes
Big brown bat	Bertie Co., N.C., 1891, 1893	3	6	no	yes
Red bat	Lake Drummond, Dismal Swamp, 1895, 1897	3	50	yes	yes
Seminole bat	Lake Drummond, Dismal Swamp, 1983	0	1	no	yes
Hoary bat	Dismal Swamp, 1983	0	1	no	yes
Yellow bat	Willoughby, Norfolk, Va., 1954	1	0	no	no
Evening bat	Lake Drummond, Dismal Swamp, 1895, 1896, 1898	13	17	yes	yes
Rafinesque's big-eared bat	Lake Drummond, Dismal Swamp, 1897	1	0	yes	no
Total specimens collected		38	89		

pairs. On 12 February 1984, a male and a female were collected at Jericho Lane, and on 15 March 1986, another male and female were collected as they flew together at the Lynn-Badger Ditches intersection. A third pair, but both males, were collected 16 March 1984 on Railroad Ditch.

The eastern pipistrelle was found throughout the Dismal Swamp. This bat, moth-like in flight and scarcely larger than a cecropia moth, was frequently observed foraging at or above the forest canopy, which made collecting difficult. Although only six were collected (Table 2), it appears to be a common permanent resident of the Dismal Swamp.

The big brown bat was most frequently found in the vicinity of Lake Drummond, where two specimens were collected as they emerged from hollow bald cypress trees, and west of the lake on Interior and West ditches. One specimen also was taken on Lynn Ditch, north of the lake.

The red bat, with 50 specimens, was most numerous (Table 2). Red bats were active throughout the sampling period whenever the mean temperature was $\geq 10^{\circ}\text{C}$. However, once (25 January) we collected three males when the temperature was only 7°C . During autumn and winter the population of red bats consisted entirely of males. Females were taken only during the months of March and April ($N = 8$; Table 2). The males ($N = 42$) were collected from September through June.

We collected 17 evening bats, *Nycticeius humeralis* Rafinesque, making them second in abundance. None were seen or collected during December and January, when we presume they were dormant. We believe that the evening bat is a permanent resident throughout the Dismal Swamp.

The remaining two species, the hoary bat and the Seminole bat, are considered rare in the vicinity of the Dismal Swamp. Both are believed to be highly migratory species, especially the hoary bat (Barbour and Davis 1969). The one hoary bat was taken in the northwest corner of the GDSNWR (Jericho and Hudnell ditches) at 1711 hours on 22 November 1983, at an ambient temperature of 11°C . The one Seminole bat, probably also a migrant, was taken at the mouth of Jericho Ditch at Lake Drummond at 1745 hours (45 minutes before sunset) on 6 October 1983, at an ambient temperature of 24°C (Padgett 1987).

Red bats changed their patterns of emergence during the year (Fig. 1). Although there was no significant correlation between time of emergence and the ambient temperature on an annual basis ($r = 0.054$, $P = 0.90$), temperature did appear to play a role in the activity patterns of red bats on a seasonal basis. From September through November, red bats foraged after sunset. As the winter progressed, they emerged and foraged earlier, and by March and April, emergence times coincided

with sunset. As spring progressed, red bats emerged later in the evening, when we would observe them with our truck headlights as we drove out from the interior of the GDSNWR.

We recorded 10 evenings with no bat activity (Table 2). On four evenings when the sky was clear and no bats were observed, the temperatures were 6° and 8°C in December, 21°C in June, and 14°C in October. In June and throughout the summer, when temperatures were high, bats appeared very late in the evening, often near last light, when the exact time of emergence could not be accurately determined. On 6 October, a warm night when no bats were flying, the moon was full. Moonlight severely restricts the activity of many bat species, because they are either avoiding predators (Fenton et al. 1977) or responding to lower insect abundance (Anthony et al. 1981). It rained on half of the six cloudy evenings when no bats were observed; the temperatures ranged from 7° to 20°C (\bar{x} = 14°C) on those six evenings, and only the 7°C recording was <10°C. However, on seven evenings with overcast skies but no rain, bats were actively foraging and subsequently collected.

DISCUSSION

Four species of bats — big brown, silver-haired, hoary, and Seminole — constitute new records for the Dismal Swamp and southeastern Virginia, and the Seminole bat represents a new record for Virginia.

Table 2. Species of bats collected by month, from September through June, 1983-1986.^a

Species	S	O	N	D	J	F	M	A	M	J	Totals
Silver-haired bat				1:0		2:1	3:1				6:2
Eastern pipstrelle		2:2	0:1							0:1	2:4
Big brown bat						1:0	1:2	1:1			3:3
Red bat	1:0	4:0	2:0	5:0	5:0	11:0	6:1	7:7	1:0		42:8
Seminole bat		0:1									0:1
Hoary bat			0:1								0:1
Evening bat	1:0	3:1	0:1			1:0	2:3	4:1			11:6
Bats collected:	2	13	5	6	5	16	19	21	1	1	89
Days sampled:	2	12	12	10	3	9	7	14	5	3	77
Days with no activity:		1	2	2			1	2	1	1	10

^aNumbers separated by colon indicate number of males and females (M:F).

In the piedmont of Virginia, Lewis (1940) found red bats to be active at $\geq 13^{\circ}\text{C}$, but Davis and Lidicker (1958) observed red bats in West Virginia only on evenings when the temperature was $\geq 19^{\circ}\text{C}$. Kunz (1982) noted that temperature is a crucial factor in controlling seasonal as well as daily activity patterns of many species of bats inhabiting the temperate zones.

During the winter, red bats emerged early but seemed to forage only for a short period of time. In the Dismal Swamp, especially in winter, the temperature fluctuates greatly, sometimes dropping as much as 10°C within an hour or less. Consequently, emergence periods during the winter were often brief; bats foraged briefly and then retired before the ambient temperature dropped below 10°C .

Many specimens collected during the winter had stomachs full of insects. During the winter we observed numerous moths as well as swarms of midges (Chironomidae) when many bats were active. The activity patterns of bats may be correlated with the presence, abundance, and activity patterns of insects, as well as with temperature. Twice we observed bats as potential prey themselves when a red-shouldered hawk (*Buteo lineatus*) and an American crow (*Corvus brachyrhynchos*) pursued a foraging bat at treetop level; in neither instance did we see the conclusion of the chases. Horsley (1991) reported seeing a blue jay (*Cyanocitta cristata*) fall to the ground while trying to subdue a red bat in Dare Co., N.C., indicating that such chases sometimes are successful for the predator.

Silver-haired bats are considered to be highly migratory (Barbour and Davis 1969). Handley and Patton (1947) and Baily (1946) believed that silver-haired bats are migrants in spring and autumn but may breed in the mountainous regions of Virginia. However, silver-haired bats were seen emerging from hollow trees in Lake Drummond during April, suggesting that they may indeed breed within the Dismal Swamp.

The species not collected during the survey may be equally significant. No species of *Myotis* was collected within the GDSNWR, although two records of Keen's myotis do exist for the Dismal Swamp (Table 1). We expected to collect little brown bats, *Myotis lucifugus* (LeConte), in part because D. Schwab (personal communication) had taken them less than 400 m from the western boundary of the Dismal Swamp, 5 km S of the Suffolk, Va., business district. Furthermore, the little brown bat is considered to be the most abundant and widely distributed bat in North America (Barbour and Davis 1969). However, this colonial bat is not known to be a tree-dwelling species and is more typically found inhabiting buildings and caves. During our survey, we searched the few remaining buildings within the Dismal Swamp but found no little brown bats. In the past, the numerous cabins and other

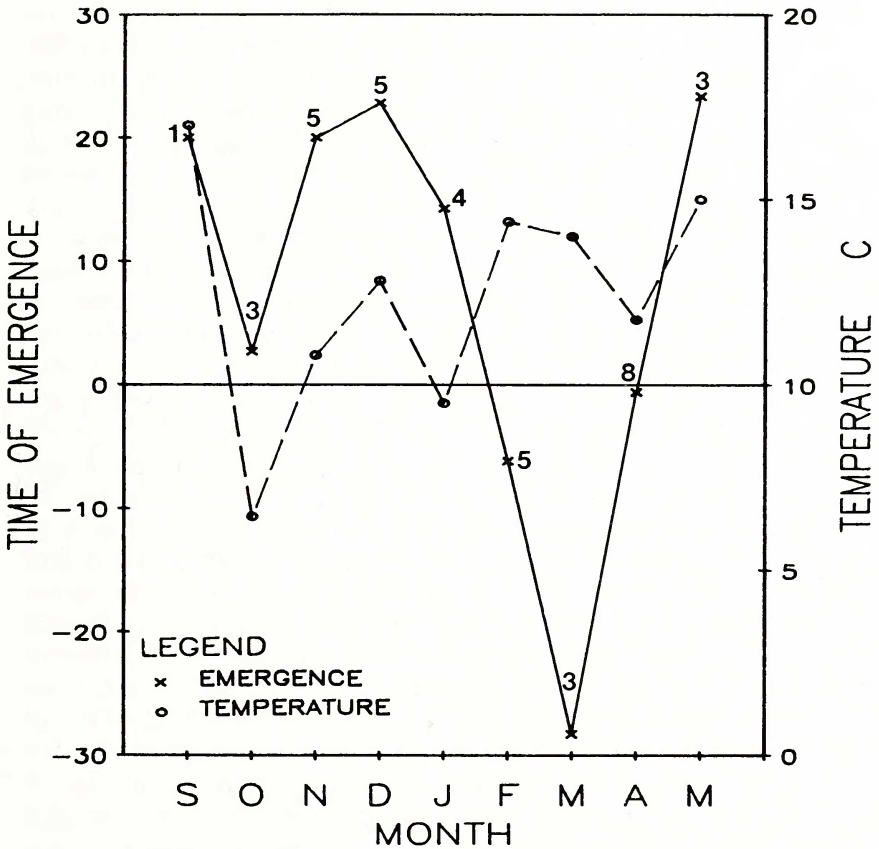


Fig. 1. Mean emergence times and temperatures for red bats (*Lasiurus borealis*) recorded from September through May, 1983-1986, in the Great Dismal Swamp. Numbers on graph represent total days sampled per month. Positive values represent emergence times (minutes) after sunset; negative values are emergence times before sunset.

buildings along the shores of Lake Drummond may have provided excellent roosting areas for this bat. Since the creation of the GDSNWR in 1974, most of those structures have been demolished for esthetic reasons and for public safety. Therefore, it is likely that absence of little brown bats is associated with loss of buildings. By contrast, Keen's myotis is a less gregarious species that sometimes roosts under the loose bark of trees (Barbour and Davis 1969), which increases the possibility that this bat still exists within the Dismal Swamp.

Another species that could occur in the vicinity is the northern yellow bat, *Lasiurus intermedius* H. Allen. At present, the only Virginia

record of this bat is a pregnant female collected northeast of the Dismal Swamp in May 1954 (de Rageot 1955). It is not known whether that animal flew there or accidentally reached the area by ship (Handley 1979a). The northern yellow bat is generally associated with Spanish moss, *Tillandsia usneoides*, which is rare in the Dismal Swamp but does occur in Seashore State Park in Virginia Beach, less than 15 km from where the specimen was collected by de Rageot.

Perhaps the most sought-after species of bat in the region is Rafinesque's big-eared bat, *Plecotus rafinesquii macrotis* Lesson. None were collected during our survey. At present, only one specimen has been reported from Virginia. It was taken in 1897 near Lake Drummond, where big-eared bats supposedly resided in hollow cypress trees (Handley 1979a). Recent circumstantial evidence suggests that this rare species still resides in the vicinity. In September 1984, a specimen was discovered on the grille of an automobile in the Pungo section of Virginia Beach, east of the Dismal Swamp. Although the specimen was discarded, 35-mm color slides of the animal were identified as being Rafinesque's big-eared bat by C. O. Handley, Jr. (personal communication). On 4 June 1989, another specimen of Rafinesque's big-eared bat was photographed and released by D. Schwab (personal communication) less than 2 km W of the GDSNWR. The recent collection of several specimens of Rafinesque's big-eared bat in Merchants Mill Pond State Park, Gates Co., N.C., within 30 km of the Dismal Swamp (Clark et al. 1985), as well as the specimen photographed by D. Schwab, suggests that the species probably inhabits the Dismal Swamp. Despite a paucity of information, the status of Rafinesque's big-eared bat has been changed from status undetermined (Handley 1979b) to endangered by the Commonwealth of Virginia.

Although we did not collect all of the species believed to occur in the Dismal Swamp, we did document the occurrence of four species of bats not previously recorded there, and we verified the continued presence of three other species not seen there for 24 to 90 years. No *Myotis* were taken in the Dismal Swamp in 77 collecting days. Male red bats and silver-haired bats were active throughout the winter when the temperature was greater than 10°C and 13°C, respectively.

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